Rice University
Civil and Environmental Engineering

CEVE 518 –CONTAMINANT TRANSPORT

SPRING 2015 Syllabus

Course objectives

1. Develop an understanding of the basic equations of groundwater flow and contaminant transport, and how to apply them to real-life problems.
2. Understand how physical, chemical, and biological processes that affect chemicals as they are transported through the environment.
3. Understand the limitations in data and our ability to accurately predict groundwater flow and contaminant transport.
4. Learn how to assimilate diverse and sometimes sparse information to draw conclusions about contamination issues through homework problems and a class project.
5. Learn the potential of groundwater and vadose zone modeling software.

Textbooks

Required:

Charbeneau, R.J., *Groundwater Hydraulics and Pollutant Transport*, Waveland Pr Inc, 2006.

Highly Recommended:

Bedient, P.B., H.S. Rifai, and C.J. Newell, *Ground Water Contamination; Transport and Remediation, 2nd Ed.*, Prentice Hall, Upper Saddle River, NJ, 1999.

Other useful references:

Anderson, Mary P. and William W. Woessner, Applied Groundwater Modeling; Simulation of Flow and Advective Transport, Academic Press, Elsevier, San Diego, 2002.

Bear, Jacob, Dynamics of Fluids in Porous Media, Dover Publications, New York, 1972.

Bear, Jacob, Hydraulics of Groundwater, Mcgraw-Hill, 1979.

Crank, J., The Mathematics of Diffusion, 2nd Ed., Oxford University Press, Oxford, Great Britain, 1975.

Domenico, P.A. and F.W. Schwartz, *Physical and Chemical Hydrogeology, 2nd Ed.*, John Wiley and Sons, 1997.

Fetter, C.W., Applied Hydrogeology, 4th Ed., Prentice Hall, Upper Saddle River, NJ, 2001.

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Fetter, C.W., *Contaminant Hydrogeology, 2nd Ed.*, Waveland Press Inc, 2008.

Freeze, R.A. and J.A. Cherry, *Groundwater*, Prentice Hall, 1979.

Pankow, J. F. and J. A. Cherry, 1996, Dense Chlorinated Solvents and Other DNAPLs in Groundwater, Waterloo Press, Portland, Oregon, 1996.

Spitz, Karlheinz and Joanna Moreno, A Practical Guide to Groundwater and Solute Transport Modeling, John Wiley and Sons, New York, 1996.

Strack, Otto D.L., Groundwater Mechanics, Strack Consulting Inc., North Oaks, MN, 1999.

Todd, D.K. and L.W. Mays, *Groundwater Hydrogeology*, 3rd Ed., John Wiley and Sons, 2004.

Zheng, Chunmiao and Gordon D. Bennett, Applied Contaminant Transport Modeling, 2nd Ed., John Wiley and Sons, New York, 2002.

Grading

Tests (2)	50%
Homework	25%
Group Project/Presentation	25%

Tests

Two tests will be given:

- A closed-book in-class test on or around February 25. You will be provided with a hand-out of important equations.
- A take-home test distributed on or around March 25. The test will be due one week after distribution.

Selected tests from current and previous semesters and solutions will be posted on OWL-Space. Because the group project will be a significant effort, there will be no final exam.

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Homework

Homework assignments will require significant effort on your part. They are designed to give you practice at applying the course material in a way that you probably will in your professional life after college. Homework assignments will generally be due 1 to 2 weeks after distribution. Assignments and solutions will be posted on OWL-Space. Grades on late homework assignments will be reduced by 10 percent of the possible homework grade for each day or part of day that they are late. Extensions can be given *with prior arrangement*.

Project

Project – Groundwater model exercise (group report). Project includes:

- Development of a conceptual model.
- Estimate of hydraulic parameters from data.
- Simulation of contaminant transport in the vadose zone.
- Construction and calibration of a saturated zone flow model.
- Construction and calibration of a mass transport model.
- Design of groundwater remediation system.
- Presentations (last day of class – April 19).
- Report (report will be due last day of finals – Date to be determined).

Instructor and Office Hours

Phillip C. de Blanc, Ph.D., P.E.
262 Mech Lab
Mobile: 281-635-6069 (Emergencies only please!)
Email: pcd1@rice.edu

Office hours 9:00 to 10:00 a.m. on class days and by appointment.

I check email regularly, and you are encouraged to communicate by email whenever possible. I will usually respond within a few hours, but never more than 24 hours later (except on holidays and weekends).

CEVE 518 Course Outline and Lecture Schedule, Spring 2015

Day	Date	Week	Subject	Reading Assignment	Other Assign/Submit
Mon	12-Jan	1	Overview of GW Hydrology - Basic concepts - Issues and course preview - Obtaining model software		
Wed	14-Jan		Hydrologic Cycle and Aquifers - Types of aquifers - Soil horizons - Aquifer and soil properties	Bedient: Chapter 1; 15 - 23 Charbeneau: Chapter 1	Hwk 1 Issued.
Mon	19-Jan	2	***No class Monday, 20 March (MLK Day)***		
Wed	21-Jan		Darcy's Law and Hydraulic Conductivity - Darcy's Law - Permeability - Hydraulic Conductivity - Layered media - Anisotropy - Darcy's Law range of applicability (Re)	Bedient: 23 - 30 Charbeneau: 18 - 37 Charbeneau: 44 - 48	
Mon	26-Jan	3	Groundwater flow - Transmissivity - Regional flow per unit width of aquifer - Head distribution in confined aquifers - Head distribution in unconfined aquifers - Unconfined aquifers with recharge - Head distribution in leaky aquifers	Bedient: 34 - 41; 49 - 50 Charbeneau: 48 - 67	Hwk 1 due.
Wed	28-Jan		Numerical flow modeling - Finite differences	Bedient: 335 - 370 Charbeneau: 428 - 430	
Mon	2-Feb	4	Numerical flow modeling - Introduction to MODFLOW		Hwk 2 issued.
Wed	4-Feb		Well hydraulics and steady flow - Steady flow to a well; confined aquifer - Theim equation - Steady flow to a well; unconfined aquifer - Image wells ***End of Exam 1 Material***	Bedient: 50 - 58 Charbeneau: 91 - 105	
Mon	9-Feb	5	Well hydraulics and transient flow - Theis equation - Jacob approximation - Radius of influence - Superposition	Bedient: 58 - 60 Charbeneau: 105 - 115	Hwk 2 due.

CEVE 518 Course Outline and Lecture Schedule, Spring 2015

Day	Date	Week	Subject	Reading Assignment	Other Assign/Submit
Wed	11-Feb		Review for Exam No. 1 Aquifer Testing and Transient Flow - Slug Test - Specific capacity test - Pumping test, single well - Pumping test, two wells - Recovery test	Bedient: 60 - 70 Charbeneau: 115 - 125; 140 - 150 Charbeneau: 125 - 138; 150 - 154	
Mon	16-Feb	6	***Exam 1 (in class)***		
Wed	18-Feb		**Field Exercise** - Water level measurement - Slug test - Specific capacity test		Hwk 3 issued.
Mon	23-Feb	7	Transient flow problems cont.	Bedient: 71 - 73 Charbeneau: 154 - 158	
Wed	25-Feb		Groundwater contamination - Sources - LNAPL/DNAPL - Vapor migration	Bedient: 75 - 98; 108 - 110 Charbeneau: 247 - 263	Hwk 3 due
Mon	2-Mar		***Spring Break - No Class***		
Wed	4-Mar		***Spring Break - No Class***		
Mon	9-Mar	8	Open		
Wed	11-Mar		Equilibrium partitioning - Air/water - Solid/water (adsorption) - NAPL/water	Bedient: 203 - 215 Charbeneau: 263 - 277; 289 - 291	
Mon	16-Mar	9	Diffusive transport ***Project Assignments Issued***	Bedient: 162 - 165 Charbeneau: Chapter 7	Hwk 4 issued.
Wed	18-Mar		Advection-dispersion equation - Formulation - Physical nature of dispersion - Estimating dispersivity - Boundary conditions - 1-D solutions	Bedient: 170 - 184 Charbeneau: 365 - 366; 373 - 378 384 - 390	
Mon	23-Mar	10	ADR equation solutions - 2-D/3-D solutions ***End of Exam 2 Material.***	Charbeneau: 366 - 373; 396; 399 - 417	Hwk 4 due.

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Day	Date	Week	Subject	Reading Assignment	Other Assign/Submit
Wed	25-Mar		Mass transport modeling - MT3D/RT3D ***EXAM 2 Issued (Take-home)***	Bedient: 371 - 384	Exam 2 issued
Mon	30-Mar	11	Groundwater Remediation - Active remediation - Passive remediation - Natural attenuation	Bedient: 479 - 497	
Wed	**1-Apr**		**Spring Recess - No Class**		
Mon	6-Apr	12	Vadose Zone - Capillary pressure - Matric potential - Soil moisture characteristic curves - Saturation/hydraulic conductivity relationships - Richard's equation - Simplifying assumptions ***Project Progress Report Due***	Bedient: 289 - 298; 303 - 315 Charbeneau: 179 - 204	
Wed	8-Apr		Vadose Zone (cont.)	Bedient: 45 - 46 Charbeneau: 218 - 229; 239 - 244	
Mon	13-Apr	13	Vadose Zone modeling - Intro to HYDRUS		Hwk 5 issued.
Wed	15-Apr		Case studies/project work session		
Mon	20-Apr	14	Case studies/project work session		Hwk 5 due.
Wed	22-Apr		Project Presentations ***Last day of class***		
Wed	6-May		Last day of finals ***Project Report Due***		Project report due.